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# D I P H T H E R I A

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DEFINITION

Diphtheria is an acute infectious disease caused by the invasion of a specific microorganism, the Bacillus Diphtheriae.

The bacillus causes a local inflammation at the point of entrance and also by the absorption of its toxic products, into the system, it gives rise to fever, definite symptoms and sequelae.

HISTORY.

Diphtheria is probably one of the oldest diseases affecting man.

Aretacus at the close of the first century after Christ describes a disease, the malum aegyptiacum, about which he says the tonsils are covered with "quodam concreto humore albo".

Macrobius mentions an epidemic at Rome A.D. 380 for which sacrifices were made to a Goddess "ut populus Romanus morbo, qui angina dicitur promisso voto, sit liberatus.

In 856 Baronius writes (annal. ecclesiast.) of a "pestilentia faucium, qua fluxione gutter obstructum citam mortem inferret" which occurred at Rome, (quoted by Hirsh Vol 3 page 73-4)

In 1515 the first mention seems to have been made regarding diphtheria otherwise than of the throat

Then Herrera described diphtheria of wounds, he looked upon the false membrane he found after death as the essential characteristic of the disease. (Jacobi treatise on diphtheria New York 1880 page 2)

Hecker (epidemics. page 224) mentions the fact that in England in 1517 there was an epidemic of " a malignant and infectious inflammation of the throat" In 1557 a like epidemic occurred in Holland, which spread to many districts of Europe (Petr. Forestus obs; lib 6., de febribus publice grassantibus, et lib 15 obs 5-11)

In 1576 a fatal form of Angina prevailed in Paris, and the discovery of a pseudo membrane at an autopsy was made by an unknown surgeon ( Ballonii opera omnia epid. et ephemer, lib 11 1576 Geneva)

A Sevillian historian Mercado, writes of a child who in 1608 gave the disease to his father by biting his finger ( Jacobi Treatise on Diphtheria page 2)

In 1771 Crawford wrote an essay (De cynanche stridula Edin. 1771)

In 1817 at Ashford in Kent an epidemic of malignant sore throat occurred. It is mentioned by Dr Burden Samderson as "an epidemic of malignant sore throat which proved extensively fatal to children, was never accompanied by any rash and differed from Scarlatina" (Thorne Natural History of Diphtheria page 15)

In 1821. diphtheria appeared for the first time in Lima.

It did not affect the Black races "who were as resistant to diphtheria as to Yellow Fever" (quoted in Dr Babington's Presidential address Transactions epidemiological Society Vol 1 Part 1, page 9)
It is possible and even probable that many of the above descriptions may not have been true diphtheria

The instances mentioned may have referred to other diseases such as scarlatina and even tonsilitis.

In 1821 we have more accurate accounts of the disease.
M Bretonneau wrote a treatise on the subject and laid it before the French Academie de Medecine.

On account of the exudation he called this form of angina diphtheritis.

"From numerous facts he believed he had proven that contagion occurred only when the diphtheritic secretion, in the form of fluid or dust like atoms came in immediate contact with soft mucous membrane or with the skin deprived of its epithelium" (Oertel Diphtheria. Cyclopaedia of the practice of medicine 1875 Vol 1 pages 575-576)

"Bretonneau at first insisted that diphtheria was a local disease, he was obliged at a later period to concede that a blood poisoning is one of its

essential characteristics" (Ibid)

He also pointed out that diphtheria and croup were the same disease and that " angina gangrenosa is not related to this affection" (Ibid)

In the years 1848 and 1849 cases of diphtheria were observed in St Thomas' Hospital, also in Hereford and Staffordshire and near Yarmouth (Quoted by Netten Radcliffe, Transactions epidemiological Society Vol 1, part 3, page 328)

In 1857 Dr Wade of Brimingham first obeserved and pointed out in the Midland Quarterly Journal of Medical Sciences 1857 that albuminuria often occurred in diphtheria. (quoted from Newsholme, origin and spread of Pandemic Diphtheria 1900 page 117)

There was a very severe epidemic in 1875 described by Dr Sainton in Bar-sur-seine, Celles-sur-ource and Mussy-sur-seine (Aube) lasting for more than a year. The inhabitants of these places numbered 5203; out of these 628 were attacked and no less than 80 died.

The mortality among boys was 1 in 5, in girls 1 in 6 and in adults 1 in 18.

Several other outbreaks occurred at this time in France (described in Dictionnaire Encyclop. des sciences medicales. page 642 tome 29)

In 1883 Klebs described a bacillus which he discovered in the membranes of diphtheric throats;

and Loffler was able to cultivate this organism on different media and also produced, in animals, by innoculation, a disease identical with diphtheria in man.

In 1894 was introduced a serum by Behring which revolutionised the treatment of diphtheria.

ETIOLOGY. History and our present knowledge of diphtheria prove it to be an infectious and contagious disease.

To complete its etiology we must consider

(1) Causa Causans

(2) Causa efficiens and

(3) Causa movens.

The causa causans is the bacillus diphtheriae, known as the Klebs- Loffler bacillus.

This organism (of which a description will be given later) is always present in the disease and is found, and can be obtained from, the false membrane.

To have diphtheria there must be this bacillus but this does not exhaust the causation of diphtheria.

The bacillus can be found in the throats of persons and yet they may have no other sign of disease.

There are undoubtedly epidemic and interepidemic periods of the disease. To have an epidemic it is essential to have the causa efficiens and the

causa movens.

These consist of the combined favouring influences of personal constitution and conditions of environment.

There is little doubt that a congested or inflammatory condition of the throat is most favourable to the reception and development of the bacillus.

So it is then that we so often see diphtheria following scarlatina.

The suitable nidus is present in the scarlatina throat and into this comes the diphtheric organism.

I was able to observe a good instance of diphtheria following scarlatina, in an epidemic which occurred in part of my sanitary district at the village of Manea in Cambridgeshire

The epidemic appeared in the autumn of the year after a dry season .

In all, the cases of scarlatina numbered 31 and the throat symptoms were severe and persistent.

I received three notifications of diphtheria referring to the same cases, which, 10 and 12 days previously ,had been notified as scarlatina.

The cases of diphtheria were all in different houses and the houses were at least a quarter of a mile apart these 3 cases started on the same day.

Seven more of the scarlatina cases developed

diphtheria and only two cases of diphtheria occurred in persons who had no signs of scarlatina. The population of the village was about 1400.

Diphtheria then, shewed a great partiality for the scarlatina cases, where the throats were in a condition ready to receive the bacillus.

How often too is found what may be called an epidemic of sore throat and an epidemic of diphtheria at the same time- Why should this be so? Possibly and perhaps probably because certain atmospheric conditions are favourable to sore throat and the diphtheric bacillus, so to speak, takes the opportunity of entering these throats.
An epidemic of diphtheria may be due to many factors Undoubtedly diphtheria spreads by direct infection and school attendance may account for many cases in this way.

The Annus Medicus Review of the Lancet (Dec 25th 1897) states " No one .. ..can have watched the weekly returns of the Registrar General, as regards the metropolis, without feeling that the waste of child life which is going on in London is a matter calling for the most careful enquiry. Nearly every one who is conversant with the subject is convinced that the increase has taken place not only synchronously with, but consequent on, the increased aggregation of children at the most susceptable age for diphtheria in our elementary schools"

It must be remembered that the school age especially the elementary school age, is very susceptible but not so susceptible as the age before it

Henock (Tirard Diphtheria and Antitoxin page 3) found

108 occurred the first year
542 from age of 1-6
107 " " 7-8
96 " " 8-14

Dr W.R.Smith Medical Officer of the London School Board in the Harben Lectures page 55 shews, that the maximum percentage of cases occurs in children from 3 to 4 that is to say before they attend school and that in subsequent years when children attend school there is a smaller percentage of cases.

School children however must run a great risk of infection from each other.

I have also seen instances of infection from bedding; one where a washerwoman contracted the disease by washing the pillow cases of an infected person.

An important source of the spread of diphtheria is to be found in milk.

Milk may be infected directly from the cow and I have traced an epidemic to this cause.

In this epidemic 4 houses were infected, these were all over 100 yards apart and were supplied with

milk from a cow which had recenly calved, and had an eruption on the teats No other houses in the village were affected.

Milk is perhaps quite as frequently infected from persons engaged in the dairy, and cases are too numerous to mention where an epidemic has started from this source.

Milk is a very good medium for the development of the bacillus.

In view of proving this a patient with diphtheria breathed into half a tumblerful of milk. After this had been standing for some time great quantities of the bacilli were found in it.

In another case I placed 12 glasses of milk, taken from a dairy 6 miles away, in a room occupied by a diphtheric case, examination shewed the bacilli to be present in two of the samples.

From these and other tests of a similar nature I have concluded that there is great danger of infection from milk which has been exposed in a sick room containing a diphtheric patient.

I feel sure that many people have contracted the disease by drinking milk which has remained in the infected room.

It is well to warn attendants of the more ignorant classes of the risk which they run from this source

While the infection of diphtheria spreads by the intercourse of human beings it is also given to man by the lower animals.

My attention was first called to this fact by a case of diphtheria in the child of a game-keeper.

I found the child suffering from diphtheric croup the diagnosis being made from the several symptoms physical signs and also confirmed by a bacteriological examination.

The source of the infection at first puzzled me as the house in which she lived was isolated on the Wiltshire Downs thoroughly cleaned, well drained with absolutely no nuisance which I could discover.

In the course of my conversation with the father he told me that two of his spaniels had died and that the child had fondled these dogs during their illness He told me that the dogs appeared to be affected in their throats and coughed up "a slimy substance" .

The dogs were exhumed and I obtained from the throat of one of them some of the "slimy substance" which, on culture and examination shewed the klebs-Loffler bacilli in great quantities.

Cats and rats undoubtedly suffer from diphtheria, and the cat being an animal so often the plaything of a child should be watched when its health seems impaired.

Dr Thorne Thorne says that " the specific bacillus of diphtheria has never to his knowledge been discovered in sewer gas ( quoted in Tirard "Diphtheria and Antitoxin" 1897 page 7) This may be so, and bad sanitation may not be the direct cause.

We well know the sore throat caused by " the smell from the sink" and so forth and it is possible that the throat so caused may become the suitable nidus for the bacillus.

Be this as it may I am very inclined to think that diphtheria is conveyed by sewage matter and the infection is given off in sewer gas.

In a village in Cambridgeshire called Doddington, in 1894 an epidemic of diphtheria and membranous croup occurred.

The first case appeared in a house situated beside an open ditch. This open ditch conveyed the sewage matter from one part of the village and it is about three quarters of a mile from the village.

The second case occurred a mile from this, at the other side of the village, close to the outlet of another portion of the drainage.

36 cases in all occurred after this and these cases followed the distribution of the drains.

At that time the traps in the road gulleys were very defective and emitted a very bad smell from the drains.

In the great majority of the other cases I found that the children had been exposed to this smell, whilst at play in the streets.
At any fate, when carbolic was freely used in these gulleys the epidemic suddenly subsided.
In the epidemic I was able to exclude the milk supply and in most cases infective intercourse.

This epidemic points very much to the faulty drainage system of the village and all although perhaps not conclusive, has caused me to look upon defective sanitation with great suspicion.

I have so far considered the spread of diphtheria from person to person, and the ways and means by which the infection is carried.

There is however more than this required to explain the outbreaks of this disease.
It is a well known fact that in nearly all European and also in American Towns, diphtheria is endemic and has been so during the past 30 or 40 years.

Why then in these endemic cities does diphtheria become epidemic at periods?

It has been somewhat carelessly stated, and I think has been the general belief that dampness in the soil and dampness in the dwelling favours the production of the bacillus.
Oertel says "the disease is not affected by either heat or cold drought or rain" (Vol 1 page 583 Von

Ziemssen's Cyclopoedia of Medicine English Trans 1878)
My own belief is that undoubtedly epidemics of diphtheria are very much more common after a prolonged period of dry weather.
It is known that a considerable increase in the number of cases of this disease begins in the third quarter of the year; the number attains its maximum in the fourth quarter and then declines, but is in excess of the number occurring in the second quarter. Now the third quarter follows after a usually dry period and the fourth quarter follows a still longer period of dryness.
The second quarter of the year following as it does after the rains of January February and March is accountable for the fewest cases of all.
In Ireland diphtheria is less prevalent than in England. Ireland is rainy, England comparatively dry
I will grant that epidemics may become severe just as a wet period begins, but it is after a prolonged dry period that this is so.
"At Croydon the average rainfall during 1867-94 was 26.3 inches. An epidemic maximum occurred in 1877 with a rainfall of 32.2 inches This followed on 4 dry years, 1873-76 in which the rainfall was 25.7 24.1, 26.9, and 26.8 inches respectively. It would appear therefore that in this, as in some other instances, dry seasons are provocative of diphtheria especially when there is a series of them and that

the epidemic may continue and even reach its maximum in the wet year which follows the series of dry years" (Newsholme origin and spread of Pandemic Diphtheria page 145)

In my Report to the Local Government Board on an epidemic occurring in Doddington in the year 1894 I pointed out that we had in this district an average rainfall of only 25.1 inches for the two preceding years.

This epidemic started in August and increased in severity until the end of November when it quickly subsided.

Rain started about the middle of November in great quantities and continued with such severity that it registered 4.5 inches from November 14th to December 31st.

This is one only of the many instances I have observed of an epidemic following an unusually dry period. It is instructive to take the rainfall in districts where one resides, for I go as far as to say that an epidemic of diphtheria may not be expected during, or for a short time after a severe and prolonged rainfall and vice versa, be prepared for an outbreak to occur after prolonged dry weather.

As regards the influence of soil on epidemics of diphtheria Hirsch quoted by Sir R.Thorne Thorne (Nat

History of Diphtheria page 17) says "the assumption that conditions of soil have some influence in the development of diphtheria, or on its epidemic diffusion is one that has no warrant".

Sir Richard however entirely disagrees with this for he states "soil and especially surface soil when considered in connection with relative attitude, slope aspect and prevailing rainfall has I believe concern in the maintenance and diffusion of diphtheria"(Ibid)

My opinion is that the soil which gives up its moisture quickly is the soil most likely to favour an epidemic.

I have noticed in the district in which I reside great variations in the distribution of epidemics of diphtheria.

Part of this is drained fen soil and the other is gravel. The former by reason of the water level in the boundary ditches is constantly imbibing moisture from these ditches. It is drawn up by capillary attraction

The gravel parts of the district on the contrary are extremely dry and hot in summer.

In ten years there has been no epidemic of diphtheria in the feh parts of the district and this contains two thirds of the population.

On the other hand, in the gravel or "high land" parts of the district (which contain only one third of the population) there have been no less than four epidemics

A soil which retains water all the year round is unfavourable and a soil which becomes very dry at times is favourable to an epidemic of diphtheria.

INCUBATION PERIOD.

Two to four days seems to be the most usual period but from the fact that the earliest symptoms are sometimes overlooked, a false idea of this period is frequently arrived at.

I have observed cases which could not possibly have had an incubation period of more than 30 hours.

I knew a mother with a burn on the forefinger who was nursing her child and who received some of the membrane on the exposed surface, shew symptoms of the disease in 26 hours.. On the other hand it is well known that seven days may elapse before the disease shews itself.

I believe a person with a previously inflamed throat has a shorter incubation period, as a rule, than one whose throat is in its normal state.

SYMPTOMS AND SIGNS OF DIPHTHERIA.

One may see various types and one might classify them into mild, medium and severe or malignant and also divide them into pharyngeal(including nasal) and laryngeal A mild case may become a medium or severe one and a medium one may become a malignant case.

1 PHARYNGEAL DIPHTHERIA (including nasal)

I shall endeavour to describe a medium case.

F.W . Age 32, Farm Foreman, helped to nurse his child who had membranous croup.

He becmae ill three days after his child He complained of nausea, loss of appetite, headache, chilliness, pains and aches, thirst, and general feverishness.

He also complained of soreness of the throat.

On examination, I found the following signs viz; Temperature 100 Tenderness and enlargement of the glands at the angle of the jaws.

The soft palate, tonsils and fauces, indeed the whole pharynx, shewed a diffuse redness.

Respiration, 24 per minute. Pulse 90 per minute

The urine was high coloured and scanty.

The intensity of these symptoms and signs rapidly increased and the general bodily weakness was more marked the next day.

The glandular swelling increased and spread to other lymphatic connections in the neighbourhood of the jaws. These became more painful, and were greatly swollen.

The pulse increased in rapidity and appeared weaker and flabby;

The respiration was quicker.

On examination of the throat and mouth, it was seen

that the tonsils had become paler themselves, but all around them the mucous membrane was an angry red.
Some hours later a haziness appeared on the tonsils and soft palate, this rapidly increased until yellowish white ragged patches appeared on these greatly inflamed parts.
These quickly ran into each other and formed a distinct membrane, surrounded by a zone of congestion.
On removing this, an intensely red surface was left behind.
Later, this false membrane had become more adherent, and could not be removed without producing bleeding.
The membrane spread and covered the whole fauces and pharynx.
Later still the membrane became tougher and darker in colour, and from the nose there came a thin discharge.
The bowels were very constipated and the appetite lost. Swallowing gave great pain.
The temperature rose but never exceeded 103, and a small quantity of albumen was found in the urine.
There was slight delirium at night.
The signs and symptoms began to subside on the fifth day and the patches of false membrane became detached and did not form again.
The patient gradually came back to his usual health,

No form of paralysis followed the attack, the membrane was examined and found to contain the diphtheria bacillus.

This case was not treated with antitoxin. I mention this because antitoxin would in all probability, have considerably changed the symptoms.

It is hardly necessary for me to quote the particulars of a"mild" class of case . Suffice it to say, that although the klebs- loffler bacillus is present in the membrane, patients may scarcely feel ill at all.

There is however a soreness of the throat and a difficulty or tenderness on swallowing.

The febrile symptoms are very slight.

There is no albumen present in the urine, and only small patches of false membrane to be seen on the tonsils, and this membrane is easily detached.

Patients with the mild form of diphtheria may even go out and attend to their duties, not in the least aware of the dangerous disease from which they are suffering.

Several of these cases have been mistaken for tonsilitis and not diagnosed correctly, until a spread of the disease has occurred or paralysis of accommodation has shewn itself in the same patient some weeks after.

To illustrate a "severe" form I will quote a case.

E.P. A girl aged 20, previously very healthy, worked

in agriculture, contracted the disease from milk. On visiting the patient who had been ill about 18 hours, I found her suffering from extreme prostration. Pulse 110, very feeble and non-resistant. Respiration 35 per minute and shallow. Temperature 103. The tongue was dry and brown.

The usual throat signs were present viz; A patch of darkish yellow membrane on an extremely angry surface covered the pharynx, tonsils and soft palate. The following day the symptoms were intensified and quantities of albumen were present in the urine. The false membrane was very tough and of a still darker colour The patient was very delirious.

On the day following, a typhoid condition had set in. The false membrane was nearly black and the whole throat presented a gangrenous appearance. The actions of the heart were extremely feeble.

The nose emitted a foul smelling thick and dark discharge. Haemorrhages occurred in the conjunctiva and purpuric patches appeared under the skin of the body and legs. The pulse rate was 150, the temperature dropped to 97. The following day the patient died .

2 LARYNGEAL DIPHTHERIA.

This form has symptoms so very different from the pharyngeal form, that it has been given the name of

croup or membranous croup.

For purposes of notification and death returns it has a separate place.

Laryngeal diphtheria may be primary, or it may be secondary, by extension of the disease from the pharynx.

It is far more common in young children.

In my own experience the proportion of deaths is about twice as great as in diphtheria of the pharynx in children of 6 years of age. The present treatme nt of this disease considerably alters the comparative death rate of pharyngeal and laryngeal diphtheria, but from a collection of cases which I obtained before the antitoxin treatment was introduced I found the following

| PHARYNGEAL DIPHTHERIA | | LARYNGEAL DIPHTHERIA |
|---|---|---|
| 50 cases | Age 6 | 50 cases |
| 8 deaths | | 17 deaths |
| 50 cases | Age 4 | 50 cases |
| 12 deaths | | 30 deaths |
| 50 cases | Age 2 | 50 cases |
| 17 deaths | | 41 deaths |

The figures have been arrived at in making out my Annual Reports concerning the health of the district to the North Witchford Rural District Council and to the Local Government Board. From these cases it will be seen that the younger the child the more fatal

is the laryngeal form.

Most of the cases of laryngeal diphtheria are secondary, and extension has taken place downwards from the pharynx.

According to Trousseau, Bretonneau and Guersant, 19 out of 20 cases start in this way (quoted by Tirard Diphtheria and Antitoxin page 28)

My own experience in this matter is totally different, in cases occurring under the age of 3 years.

In three epidemics I made a special note of this, and found 15 out of 20 cases, in children under three years, start primarily in the larynx; these had no pharyngeal symptoms or signs whatever.

In 9 cases out of 20 I found this was also the case between the ages of 3 and 4.

Between the ages of 4 and 5 I found 3 started with a primary condition in the larynx out of 20 cases.

Over 5 years of age, I have found that the disease has spread from the pharynx.

Not in a single case over this age have I found the larynx to be primarily involved.

It is a pitiable sight to see a young child with the larynx implicated, and I quote a case to best illustrate the conditions.

E.L. A child 3 years of age, previously healthy, appeared "dull" to her mother for two days previously.

On seeing the child I found that the signs and symptoms of croup had already set in. She was breathing stridulously and hurriedly, frequently coughing with that peculiar cough which has a slight metallic ring in it.

The child occasionally put its hand to the throat and spoke with great difficulty Temperature 101 Pulse 140.

The next day these signs were still more marked. The clutching at the throat was more frequent and the breathing was louder. The extraordinary muscles of inspiration were brought into action. The supraclavicular spaces were very much depressed and the lower ribs, instead of moving outwards, were depressed.

The face was very pale and slightly cyanosed.

The whole body was covered with a clammy sweat, the temperature had fallen to normal, but the pulse was 155.

The child had expelled two successive membranes in their entirety, and after each there was a considerable amount of relief. For a short time the child was able to speak a little, but the membrane formed again, the severe symptoms returned, and finally a typhoid condition set in with a fatal result

The voice of laryngeal diphtheria varies considerably and is for the most part dependent upon the state of the membrane at the glottis.

It may be only weak and husky but it often becomes quite inaudible. The cough likewise may be present at times and then lost. After a period of loss of voice and even cough, these may return with all their metallic characters.

The reason for this may be seen by watching a case of croup.

The membrane during the extreme efforts of expiration, becomes detached, and a violent fit of coughing causes this to be ejected; then the child may begin to speak with a very natural voice until the accumulation of membrane at the glottis causes complete aphonia to again set in.

The attacks of dyspnoea vary in severity for the same reason.

Frequently, these attacks come on suddenly, and the child is, for the time, nearly suffocated.

These attacks are intermittent and usually followed by a restful period after the membrane, or part of it has been detached and expectorated.

The membrane forms with great rapidity, and although at one hour the child may appear on a fair way to recovery, an hour later will see the child struggling

for its life.

COMPLICATIONS AND SEQUELAE.

I have already spoken of the extension of the diphtheric condition to the larynx. It may of course extend to the trachea, and in various directions to the nose ear and eye.

It may affect wounds.

There may be albumenuria. It frequently leaves dilitation of the heart and many deaths are due to cardiac syncope.

Cardiac failure is one of the most serious of the complications; I have found this, in many cases, come on without any warning whatever.

I have left a patient with what might be considered a good pulse, and with a heart beating regularly and well.

Three hours later I have found this patient in the last stage of collapse.

More often however certain signs present themselves. A very rapid pulse is a warning; especially if it is irregular in force and rhythm.

Cardiac failure may be looked for, when the first sound of the heart is very short, and if the intervals between the sounds are disturbed; Cardiac failure should be one of the most"expected" signs in diphtheria, not only when the fever is at its height, but when the

patient is on his way to recovery.

I have seen many deaths from cardiac failure during convalescence because the parent has allowed the child to sit up too long or exert himself too much.

At post mortem examinations I have seen, by no means infrequently, dilitation of the right ventricle, but no endocarditis; and I have as yet failed to find a dilated left ventricle.

Pneumonia, bronchitis, collapse of the lung and emphysema are complications of diphtheria, likewise also may be mentioned thrombosis and haemorrhages which occur in malignant cases.

Of the sequelae the most important is paralysis in one of its many forms.

The symptoms of this occur, as a rule, from the third to the fourth week.

Undoubtedly older patients are much more liable to paralysis than the younger ones. In babies I have rarely seen it.

In a hundred cases of diphtheria I had the following results;

| | |
|---|---|
| 25 cases over 20 - | 3 cases of paralysis |
| 25 cases over 15 and under 20 | 1 case of paralysis |
| 25 cases over 10 and under 15 | 1 case of paralysis |
| 25 cases under 10 | No case of paralysis |

It has hardly been my experience to find, that the more severe the attack is, the more likelihood is there

to be paralysis; indeed I have known more than one case in which paralysis of accommodation has led the Doctor to ask "Have you had a sore throat lately?" and the answer has been "Yes".

Now these cases must have been very slight, so slight indeed that the case required no medical assistance or the Practitioner had not even diagnosed diphtheria

During the feverish stage of the disease paralytic symptoms can sometimes be detected.

The knee jerk is frequently abolished in the early stage of diphtheria, and it is to be noted, that in fatal cases, the knee jerk disappears as early as the sixth day of the disease, but in cases which survive the knee jerk disappears, from the fourth week until about the eighth week.

It is a sign that I think should always be looked for, and it can be tested by grasping the Rectus Femoris while the patient is on his back, instead of allowing the legs to dangle over the edge of the bed. (It is not always advisable to raise the patient)

Paralysis of the soft palate is very often first affected, and I here quote a case.

K.R. aged 6, had a mild diphtheria attack three weeks previously. The patient snuffled, and appeared to have the nose stuffed up; he could not speak distinctly.

The parent informed me that some water came down his nose when he tried to swallow it.

He "snored" in his sleep The voice was distinctly nasal. Examination shewed the right side of the palate to have dropped and it was insensible to a prick.

Paralysis of the eye is very common. The power of accommodation is temporarily lost ; the vision being hazy.

The sensory nerve arrangement is not affected. The pupil does not contract the light properly. We may indeed have the muscles of the eyeball affected, and get a squint and partial ptosis.

I have seen cases where the eyes were both absolutely paralysed and unable to move.

In addition to the knee jerk being lost, we may get paralysis of the limbs, both lower and upper.

Frequently, pain and tingling precede this paralysis As a rule it is not quite complete, but the limbs may be quite useless. The muscles soon begin to atrophy The paralysis may spread over all the limb or be patchy

Sensation frequently is not so much lost as muscular power.

Paralysis while affecting the intercostal muscles may affect the diaphragm by itself.

The following case may illustrate this fairly well.
N.F. 5 years, had a history of diphtheria 5 weeks past, I was sent for and visited the child who was suffering from severe dyspnoea, she hardly spoke at all and was very apathetic. She had a curious, low sounding cough.
The intercostal muscles were working properly. The palate was not paralysed. The heart was normal and the pulse fairly good.
There was no paralysis of the limbs, or loss of the knee jerk.
The epigastric angle was widely opened during inspiration.
The diaphragm did not move. In about three weeks she recovered completely.

The variation of diphtheric paralysis is one of the curious features of the disease; it may affect nearly all the muscles of the body, and undoubtedly, paralysis of the heart may occur through implication of the vagus.
I have never seen any paralysis of the bladder but have once observed it in the rectum.
In this case little else was affected.
The sensation in the rectum was in no way diminished but the operation of removal of faeces was attended at times with considerable pain.

The rectal paralysis occurred 4 weeks after the onset of the attack of diphtheria and lasted for about 17 days.

In this case, the only one I have ever come in contact with, recovery was complete.

I here quote a case which may illustrate the number of paralytic parts that may appear at the same time.

E.Y. Daughter of a Blacksmith, had a medium attack of faucial diphtheria.

She was so far recovered that she could walk about for an hour or so at a time. On returning home one day, she was overtaken by a thunderstorm, and she attempted to hurry. She fainted near home, and had to be carried in.

I saw her within about 15 minutes of this, and found she had partially recovered from her faintness, but was unable to stand.

The knee jerk and ankle clonus were lost.

She was ordered to bed, and some 8 hours after, I found she was unable to see properly, in fact the muscles of accommodation were paralysed in addition to the external rectus.

At that time there were no further signs of paralysis The next day however, the diaphragm was paralysed, and speech was practically lost.

She was unable to sit up, and the pupils were widely dilated. The deltoid muscles of both arms were paralysed.

The same evening (eight hours later) she was suffering from paralysis of the intercostal muscles.

Up to this time, with the exception of the first day of faintness, the heart's action had been fairly well sustained, and it had shewn no signs of collapse

The pulse rate had been between 80 and 100 per minute.

The next morning the patient presented a cyanosed appearance. The pulse rate was 145 and it was very feeble.

It appeared to me that the vagus had become implicated. The girl died two hours after this symptom first shewed itself.

MORBID ANATOMY.

The naked eye does not see much beyond the false membrane.

This is, as a rule found to be more adherent to the mucous membrane on the palate than that attached to the larynx, trachea and nasal fossae.

The mucous membrane underneath is sometimes in an necrotic state, but not deeply ulcerated, as is often seen in scarlatina.

In cases of croup one often sees collapse of the

lungs, but not so often in diphtheria that has been unattended with paralysis.

The muscle of the heart may be found softened but I have never seen endocarditis. The muscle is very often, especially after paralytic cases, in a state of fatty degeneration.

I have seen the false membrane descend as low as the duodenum in two cases, and as far as the length of the oesophagus in five cases.

The kidney may present all the usual appearances of acute parenchymatous nephritis when albuminuria has been present during life.

The epithelial cells often shew cloudy degeneration

The nervous system, in cases where no paralysis has occurred, shews nothing abnormal, but where paralysis has been present during life, great changes are sometimes seen; these are mainly are at the peripheral ends of the nerve of the affected part. Here may be seen parenchymatous degeneration and total disappearance of the white substance of Schwann and it is noticeable that only certain fibres are affected. The muscles supplied by these nerves frequently shew fatty degeneration.

The false membrane itself, presents under the microscope, on section, the following; a great number of leucocytes, embedded in masses of fibrin

Loose threads of fibrin, red blood corpuscles and cell nuclei, are to be seen.

Deeper, are to be found, cells of the epithelial type shewing frequently their outlines with no nuclei.

The mucous membrane and the false membrane do not shew a definite line of demarcation between them. They join each other irregularly.

The blood vessels of the mucous membrane are enlarged and congested. Sometimes little haemorrhages are to be seen round them; they are sometimes thrombosed.

If the membrane is examined in a late stage, one may see a large number of fatty globules, cholesterin and crystals of the fatty acids.

A great number of sceptic microbe organisms are present.

It contains, of course, large numbers of diphtheria bacilli.

The bacillus was first pointed out by Klebs in 1883 and the following year its relation to the disease was demonstrated by Löffler, by experiments on animals

It is a polymorphic organism, measuring in length 2-6 m and in breadth .5 to 1 m.

It generally shews a swelling at the end, sometimes at both ends. Sometimes the bacillus looks like a club; it is seen in the latter form, as a rule in old cultures.

There are two forms, the long and the short, and each form retains its characters under cultivation. The bacillus is non-motile and does not form spores The method I usually adopt, in obtaining a bacteriological examination, and I find it is most reliable, is the following viz;- mount on a stiff wire a swab of sterilised cotton wool.

This is to be pressed and rotated against the diseased surface, so that the cotton wool is thoroughly impregnated.

The impregnated swab should now be gently rubbed over the surface of the blood serum in a culture tube, to insure insemmination.

The tube should now be incubated at 37° C. The culture may be examined after 16 hours, or from that to 24 hours. It is possible, but not so reliable, to make a cover glass preparation direct from the swab, at the time it is taken, and at once examined. I generally do both and I find it is good practice, as in many cases, time is saved, and one gets the confirmation of the first examination, by examination of the culture.

Frequently, one fails in the immediate examination and succeeds in the culture examination.

It must however be remembered, that if one gets a negative result from even both these examinations,

it is by no means conclusive that the case is not one of diphtheria.

I have entirely failed to find the bacillus in three attempts and I have also sent swabs, from the same throat, to various laboratories with the same result, yet the case has presented all the symptoms of diphtheria, including paralysis.

The diagnosis of diphtheria must not be founded on a bacteriological examination alone, but by this examination, backed up by clinical signs and symptoms

I always make three examinations, and even if I fail in all these, if the clinical signs of diphtheria are prominent, I satisfy myself, that the case is one of diphtheria.

DIAGNOSIS.

While therefore, the presence of the Klebs-Löffler bacillus is practically diagnostic of diphtheria, its absence, in examination, does not discount the fact that the case is one of diphtheria.

Pharyngeal diphtheria must be distinguished from

1 Follicular Tonsillitis.
2 Thrush
3 Quinsy
4 Syphilitic angina
5 Scarlatina

1. Follicular Tonsillitis.

1. Probably follicular tonsillitis resembles diphtheria more than any other disease.

If however, one has a typical case of follicular tonsillitis, where both tonsils are swollen, the follicles standing out and distended with exudation, the diagnosis is an easy matter.

Sometimes however, in tonsillitis, the exudation spreads from the yellow points over the surface of the tonsil and thus simulates diphtheria.

Usually in follicular tonsillitis the temperature is higher at the start of the condition,; in children often it is 104 degrees.

There is also, usually, more pain in this condition than in the early stage of diphtheria, neither is there the glandular enlargement that we have in diphtheria. There is no albuminuria in acute follicular tonsillitis. Tonsillitis is confined to the tonsils and spreads nowhere else.

Diphtheria is not confined, but even if it starts on the tonsils, it quickly spreads to adjoining parts.

2. Thrush. This is found in patches, sometimes these patches are joined and form a complete covering over the soft palate.

In itself, it gives rise to no constitutional symptoms.

The oidium albicans can be detected in this condition

3. Quinsy. This should not give much trouble to diagnose.
Generally there is more pain and a lot of fever. Pus quickly forms in quinsy, but it hardly ever does so in diphtheria.
4. Syphillis. In the secondary stage there may be white patches on the throat caused by coagulative necrosis of the epithleial cells.
In the tertiary stage there are ulcers, the floors of which are covered with white; these however are depressed, the diphtheric membrane is raised. In secondary syphillis there is a rash with hardly any fever.
The absence of history of the primary condition in syphillis is so often withheld that the absence of this history is often of no value.

It is only however, in the case of an epidemic of diphtheria, that one is likely to mistake syphillis for diphtheria.
5. Scarlatina. I think this diagnosis presents great difficulties; especially when an epidemic of each disease is present in the same district at the same time.
The throat in scarlatina often shews a false membrane and the lymphatic glands are enlarged early in the disease.

There is one point however to assist one and that is, the submaxillary glands are more often affected in scarlatina. The glands, moreover, are more severely inflamed in sacarlatina and they frequently suppurate at an early stage.

It is not usual for the false membrane to extend into the larynx in scarlatina.

When a membrane exists in scarlatina, it is more purulent, and on separation from the mucous membrane, it often leaves deep ulcers.

Vomiting usually occurs very early in scarlatina; if it occurs at all in diphtheria, it is late.

The temperature is a very important point.

In scarlatina it is very high, in diphtheria it is much lower.

Very rarely a rash shews itself in diphtheria, as is the case in scarlet fever. If it should occur in diphtheria it does so much later than in scarlet fever.

Such, seem to me, to be the principal points which separate the two diseases.

It must not be forgotten that the scarlatina throat forms a suitable nidus for the Klebs-Loffler bacillus and reference may be made to page 6 of this essay.

In all the above cases where diagnosis is required the recognition of the bacillus diphtheriae is sufficient, but it is not always recognised.

In all cases the bacteriological examination must be made, and it should invariably be made where a

a scarlatina case is followed by signs of diphtheria in the throat.

Finally, in making a diagnosis of diphtheria, one must be very careful not to be deceived by the pseudo-diphtheria bacillus or Hoffman's bacillus. These may be seen microscopically as short wedge shaped rods. They are generally situated with their bases in apposition, and are in pairs.

The Colonies appear identical with the true bacillus The Hoffman's bacillus has no effect when injected into animals.

Another form of pseudo bacillus - called the Xerosis bacillus- can usually be detected in conjunctival inflammation It is very like the long variety of the diphtheria bacillus, but it is more curved, and is often arranged in a rosette form.

The Colonies do not develop nearly so quickly as the true bacillus, when taken from the body, at the body temperature; rarely until 48 or 50 hours.

It is non virulent when injected into animals .

The diagnosis of the different paralyses of diphtheria should present little or no difficulty; there is the history of sore throat, and the paralysis runs such a peculiar course. Then, one usually gets early paralysis of the palate and eyes; these are not often affected in other forms of peripheral neuritis.

PROGNOSIS.

Although of recent years, the prognosis of diphtheria is more favourable, I have never yet met with a case, however slight, in which anxiety need not be felt. One feels anxious even in the simple case of faucial diphtheria, lest it should involve the larynx or later, give rise to serious paralysis or cardiac failure. I make it a rule to expect everything, even in a simple case, and my prognosis is guarded, accordingly. Not only is anxiety to be felt at the beginning, but that anxiety is prolonged, because of the various sequelae.

It is essential that every symptom should be carefully weighed.

The age of the patient has influence on the prognosis, also the site and severity of the attack; there is also the existence of complications, and later, of sequelae, to influence the prognosis.

Diphtheria is most dangerous under the age of three years.

The mortality decreases as years go on intil 20 is reached. After 20, I have had a higher mortality than between the ages of 15 and 20. After 30 the death rate has again been higher than between 20 and 30.

Sanitary surroundings have a great effect on the disease; I have found cases treated under bad surroundings, succumb, where similar cases, treated under good conditions, have recovered.

Again, epidemics occur in different severity, and individual cases frequently vary with the character of the epidemic.

It is not unusual to find an epidemic attacking a great number of persons, who nearly all recover; on the other hand, it is to be observed, that an epidemic may bring with it a high percentage of deaths.

The various symptoms affect the prognosis.

If a large surface be covered with membrane, there is greater danger, possibly, because the toxins are absorbed in greater quantities from a larger surface.

There is also a greater fear of the membrane affecting respiration.

Certainly, when the nasal passages and the larynx are complicated there is extreme danger.

Cases are unfavourable where nourishment is refused.

Laryhgeal diphtheria is dangerous because of asphyxia, and also because of lung trouble following later.

In all cases of malignant diphtheria a case of which is described on pages 19 and 20, a fatal termination may be expected unless one gets very good results from

from antitoxin injection.

Again, it must be remembered that paralysis of the heart may occur at any stage of the disease, leading to a fatal termination.

This may take place with little, or no warning, and in a very short space of time.

A case which came under my observation may illustrate this - A child of 7 years of age had an attack of faucial diphtheria, it presented no malignant symptoms. There was no heart disease, the pulse had never exceeded 90 per minute. The child had taken nourishment well, and had "practically recovered"

On the seventh day after the first symptom, I visited the patient, she was sitiing up in bed and playing with toys.

The parent told me "she was much better, that she had been laughing and had had an egg for her tea".

I found the patient to all appearances as the mother had stated. I examined the heart and found nothing unusual; the pulse was 80 per minute, regular, with a good resistance; temperature normal; throat clear with very little congestion.

Four hours later, I received a message to visit the child; the messenger stating she was much worse.

I found a very rapid pulse, and the patient in a state of profound asthenia, very pale, and taking no

notice of anything. The temperature had fallen to 97 degrees.

The child vomited frequently,

In spite of the administration of oxygen and the injection of strychnine and strphanthin, the child died two hours later. I attributed this death to cardiac paralysis, and it is instructive , as being one of the many cases that have, when everything else appeared to be going on well, suddenly taken a fatal turn.

Frequently one has indications however of approaching cardiac failure.

The pulse in diphtheria is always rapid in comparison with the temperature.

This rapidity is due to asthenia and is not due to rise of temperature. One does not object to a rapid pulse so much, as one that <u>varies</u> in rapidity A pulse also when it becomes irregular in force and rhythm is indicative of approaching heart failure. Sometimes an extremely slow pulse is a very bad sign. I have particularly noticed this in a great many cases; it is more especially dangerous if there are no great signs of improvement in other directions at the same time.

Vomiting and diarrhoea, restlessness and progressive emaciation are all grave signs.

As regards the prognosis in paralytic cases, it must depend upon the degree of paralysisand the parts involved.

If the ocular muscles, the pharyngeal muscles, or the extremities are only affected one may give a very hopeful view.

If however the respiratory muscles are affected, there must of necessity be great danger of pulmonary complications.

Should the diaphragm be affected alone, or the intercostal muscles alone I have generally seen recovery. Indeed, when both are affected together a fairly hopeful view may be taken, Alb

Albuminuria, in itself, is not dangerous, but the class of case it occurs in, is, because it is generally to be found in the severer type of the disease.

Finally, prognosis in diphtheria must be given with the utmost caution; the Practitioner who is too sanguine will, sooner or later, come to grief.

TREATMENT.

The treatment of diphtheria must necessarily vary with the stage of the disease. It must likewise vary with its situation, that is to say, pharyngeal diphtheria does not call for the

operative interference that the laryngeal form often requires.

Yet, up to a certain point, the disease, in whatever form it presents itself, calls for certain lines of treatment.

The general treatment of diphtheria is of the very first importance.

It must never for a moment be forgotten that it is an extremely weakening disease, and not only is this the case, but from the onset, sudden collapse may at any moment be expected.

Absolute rest in bed, with not too high a pillow is essential.

The patient must never be allowed to get out of bed for convenience, but the use of the bed pan must be enjoined.

Many a case has been lost owing only to the fact that exertion, on the part of the patient, has been permitted.

Ventilation and a good supply of oxygen and light are necessities.

Food should be in concentrated form, and easily digested; the various meat extracts are of value such as Brand's essence of beef, and especially Valentine's meat juice, also milk, broth, and good beef tea.

I do not advocate the use of stimulants so much at the outset of the disease as when the temperature falls.

Brandy, which should always be ready at hand, to be used in cases of faintness, I have always found the most reliable and to many patients the most palatable. It is well to use it in small doses about every two hours after the temperature has fallen.

The treatment of diphtheria has undergone a complete shange of late years, owing to the providential introduction of Behring's antitoxin, or anti-diphtheria serum.

It has had the effect of converting a most fatal disease into one, where the greatest hopes of recovery may be entertained.

It is the golden rule in the treatment of diphtheria that antitoxin should be injected without any delay whatever.

I would not, and do not, wait until, by a bacterial examination, I have satisfied myself that a case is really diphtheria, I attend to this, in doubtful cases, after I have used the antitoxin.

If the case should not after all turn out to be diphtheria, no harm whatever has been done; on the other hand much time has been gained, if it is diphtheria.

I make it a rule to give 2000 units, on suspicion, and back this up by 2000 more when the case is verified.

Antiseptic precautions are quite essential and the utmost care in this respect should be taken.

The subcutaneous injection is the best mode of giving the serum in ordinary cases. In cases where the Medical Attendant is called in late, it may be necessary to give it intravenously.

Even the late administration of antitoxin may do good, as it prevents the further absorption of toxins.

It seems to me that the value of antitoxin, lies in the fact, that it prevents the combination of the toxins with the tissue cells, it also prevents the phagocytes from becoming injured by the toxins, thus leaving them free to fight the diphtheric bacilli.

The antitoxin treatment may be repeated if there is much membrane, and pushed further still, if unfavourable signs shew themselves.

I agree with Dr F.Foord Craiger (British Medical Journal Oct 8 1904 page 903) when he says, he believes that one single dose is a mistake, and that it is better to administer the antitoxin over a longer period - several days - so long in fact, as there is

any evidence of activity in the local process.
I believe in doses varying from 2000 to 6000 units; according to the severity of the case.
From my own experience I have known no contra-indications to its use, and when writers have said, that it causes albuminuria I think they have mistaken the albuminuria of diphtheria for any caused by antitoxin.
I have used it when acute nephritis has co-existed with diphtheria, and it did not in any way harm the patient,
The rash which follows its use, is of no consequence, and even the arthritis which sometimes occurs, is not a serious matter.

In addition to antitoxin treatment, it is well to assist by attacking the membrane, and point of infection, with local remedies; thus in nasal diphtheria, it is useful to syringe out the nasal fossae with an antiseptic, and astringent lotion. Of all the various antiseptics that may be used for this purpose, I prefer a solution of formalin, ( 1 in 200). One may also use perchloride of mercury, ( 1 in 2000), or a weak solution of chlorate of potash; a very useful solution is chinosol ( 1 in 600).
In pharyngeal forms the same solutions may be used,

A ball syringe is very useful because one hand is free and the force can be well regulated.
I am very fond of painting the throat especially where parts of the membrane have become detached, with iodine, but I do not believe in caustic applications, or in removing firmly adherent membrane.
In laryngeal forms, antitoxin seems to work marvels, and it is in this form that it must be pushed.
I usually start with 4000 units, even in a child of two years.
It is well to wait, to see what effect this has, before resorting to operative measures.
It may however be necessary either to perform tracheotomy or intubate; this will depend on the amount of stridor and the urgency of the dyspnoea, also on the degree of cyanosis.
Neither operation is required so often of late years, because antitoxin usually brings about an early separation of the membrane and consequent relief of the patient.
Of the two operations, I much prefer tracheotomy, in fact I have discarded intubation altogether.
I do the operation as far down the trachea as possible in order to keep below the membrane.

Certain drugs are of great value in the internal treatment of diphtheria.

All drugs likely to depress the hearts action are to be avoided.

Quinine is a useful antipyretic and it has antiseptic properties; it may safely be used in the early stages.

Perchloride of iron is also very useful.

Chlorate of potassium I do not care about very much; it certainly should not be used when there is albuminuria.

Strychnine is probably one of the best remedies in the disease; it may be used from start to finish, either by the mouth, or as a hypodermic injection. Besides sustaining the heart in the earlier stages it is certainly the one sheet anchor in the various forms of paralysis..

I believe in giving large doses and I concur with Dr Nash (Practitioner April 1905 page 514). In this he states "to some children he has given nearly half a grain of strychnine a day, in divided doses, during several consecutive days .. .. ..During 1904 he treated 32 cases, without a death. During 1901 1902, and 1903 he treated 147 cases with only 11 deaths".

Digitalis would be useful, were it not for the nausea it causes, and its effect on the peripheral blood

vessels, causing much strain on the heart.
A much better cardiac tonic is to be found in Strophanthus which has none of these unpleasant effects; it rests the heart by slowing its beats, or rather by increasing the interval between the beats.
I do not think the value of strophanthus can be too highly estimated in diphtheria.
For paralysis strychnine or Easton's Syrup are probably the best remedies.
It may be necessary to feed these cases with peptonised foods per rectum, or with the nasal tube.
Lastly a diphtheric patient must be isolated, and every care must be taken to prevent the spread to others.
It is well to inject antitoxin into other members of the household; indeed, one should use every possible means of preventing, as well as curing, this terrible disease.

March



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